


Memorandum

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To: JAMES HSIAO
Project Manager
Project Management – North Region
Division of Program/Project Management
District 04

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Miner Slough Bridge
Bridge Replacement Project
EA: 04-0G660
PID: 04 00000343

From: RICK MACALA 
Structures Hydraulic Engineer
Office of Design and Technical Services
Structure Hydraulics and Hydrology Branch
MS #9-HYD-1/2i

Subject: PRELIMINARY HYDRAULIC REPORT FOR THE MINER SLOUGH BRIDGE (BR. NO. 23-0035) REPLACEMENT/REHABILITATION PROJECT

This preliminary hydraulic report (PHR) is a revision to and supersedes the September 22, 2014 PHR for the Miner Slough Bridge Replacement Project located on State Route 84, Post Mile 12.09 in Solano County, California.

Per your request, a revised preliminary hydraulic analysis was conducted for the updated Miner Slough Bridge (Br. No. 23-0035) replacement/rehabilitation project (PID 0400000343). The project now proposes two design alternatives: a bridge replacement alternative and the new bridge rehabilitation alternative.

The replacement alternative includes a complete replacement of the existing Miner Slough Bridge with a new bridge on a new roadway alignment, approximately 100 feet downstream of the existing bridge. The replacement alternative bridge is a four span structure consisting of two approach spans (Spans 1 and 4) of either a cast-in-place reinforced concrete slab or a precast/pre-stressed I-girder structure and a concrete deck over a steel girder swing span structure (Spans 2 and 3), all supported on cast-in-steel shell (CISS) concrete piles.

The rehabilitation alternative proposes to rehab the existing Miner Slough Bridge with three new approach spans (Spans 1, 4, and 5) founded on CISS piles and replacement of the deck and wooden stringers of the existing swing span (Spans 2 and 3).

The following evaluation is based on an office review of the proposed replacement alternative Planning Study Plans dated 7/21/2015; the proposed rehabilitation Planning Study Plans dated 7/10/2015; proposed and existing roadway profile grade information; structure maintenance and inspection records; existing as-built plans from various repair jobs; a preliminary geotechnical evaluation dated 1/11/2010 provided by the Office of Geotechnical Support; and field reconnaissance including photo documentation performed by Structure Maintenance. Hydraulic analyses were calculated using the U.S. Army Corps of Engineers' (USACE) one-dimensional,

steady flow river analysis hydraulic software HEC-RAS (v. 4.1.0); topographical land surveys provided by photogrammetry and ground surveys provided by the Office of Preliminary Investigations' survey crew; the USACE Operation and Maintenance Manual-Sacramento Flood Control Project, Unit No. 105: Levees around Ryer Island, Reclamation District No. 501; the USACE Levee and Channel Profiles for the Sacramento River Flood Control Project, dated March 15, 1957; and the Caltrans' consultant CH2M-Hill technical memorandum titled "*Miner Slough Bridge Replacement: Sea Level Rise Impact Assessment*" (dated May 2015).

All hydraulic and scour information in this report is **preliminary** and subject to change pending further analysis that will be completed as part of the Final Hydraulic Report.

GEOGRAPHICAL REFERENCE

All vertical elevations in this report are referenced to the North American Vertical Datum of 1988 (NAVD-88).

The NAVD-88 elevations referenced in this report can be converted into the National Geodetic Vertical Datum of 1929 (NGVD-29) datum by the datum shift formula of: $NGVD-29 = NAVD-88 - 2.44 \text{ feet}$. This datum shift was obtained from the National Geodetic Survey software, VERTCON (v. 2.0).

DESIGN OBJECTIVES

This preliminary hydraulic evaluation addresses the introduced hydraulic and scour impacts of replacing or rehabbing the existing Miner Slough Bridge and the impacts to the floodway of Miner Slough. Due to the fact, the proposed project is in an area vulnerable to sea level rise (SLR) the hydraulic analysis will include an assessment of the impacts of SLR to the Miner Slough Bridge and its adjoining floodway.

To determine if the proposed project would have any adverse effects to the floodway of Miner Slough and the impacts of SLR, several hydraulic models were developed using the HEC-RAS hydraulic program to simulate all aspects of the proposed project. Three specific hydraulic plans were modeled to cover all aspects of the design and anticipated conditions:

1. Existing Conditions Plan (pre-project conditions),
2. Replacement Conditions Plan (post-project conditions of the replacement alternative), and
3. Rehabilitation Conditions Plan (post-project conditions of the rehabilitation alternative).

The Existing Conditions analysis characterizes the hydraulic conditions at the existing Miner Slough Bridge and sets the baseline design floodwater elevations throughout the project location. The Existing Conditions Plan will also include all scenarios of SLR projections as described in the following sections of this PHR. The Replacement Conditions analysis characterizes the post-project flood impacts and hydraulic conditions of the proposed replacement structure for the Miner Slough Bridge. The Rehabilitation Conditions analysis characterizes the rehab changes to the existing Miner Slough Bridge. In addition, all hydraulic plans included floating debris loads on all bridge foundations per USACE requirements (all vertical elements, such as piles, will include a debris load that is double the width of the vertical element and extending down 2.0-feet below the design water surface elevation).

FLOODPLAIN ANALYSIS CONSTRAINTS

The assessment of the project flood related impacts were influenced by primarily three design and analysis constraints. The design and analysis approach used to address these constraints are addressed below:

Impacting the Designated Floodway of Miner Slough:

According to the California Code of Regulations – Title 23 *Waters*, enforced by the Central Valley Flood Protection Board (CVFPB), Miner Slough is under the jurisdiction of the CVFPB. Therefore, the project of replacing or rehabilitating the existing Miner Slough Bridge cannot “unduly impeded the free flow of water in the floodway or jeopardize public safety”. The post-project flood elevations cannot exceed the existing base flood elevations that would cause flooding or hinder flood flows from being carried away from the floodway. Through hydraulic modeling within the Miner Slough floodway (both upstream and downstream of the project location) it will be determined if the post-project flood elevations cause any adverse conditions within the floodway. To accomplish this, Caltrans will maintain flood elevations below a maximum standard of 0.1 feet. This 0.1 feet maximum rise in floodwaters was suggested by the CVFPB and the USACE.

Meeting Design Standards Regarding Floodway Freeboard:

The CVFPB has set standards regarding the construction or modification of bridges within a floodway under their jurisdiction. According to the California Code of Regulations – Title 23, Section §128, “the bottom members (soffit) of a proposed bridge must be at least three feet above the design floodplain”. The proposed Miner Slough Bridge will be designed to maintain at least 3.0 feet of freeboard from the post-project floodwater elevations and the bridge’s soffit elevation.

Sea Level Rise Impact to the Miner Slough Floodway:

In 2008, California Governor’s Executive Order S-13-08 was issued to direct State agencies planning construction projects in areas vulnerable to SLR to begin planning for potential impacts by considering a range of SLR scenarios for the years 2050 and 2100. Caltrans must implement the impacts of these SLR scenarios to the State Highway System.

With Miner Slough in an area of the California Delta region that is vulnerable to SLR, the proposed bridge alternatives must take into account the impacts of SLR. Therefore, various SLR scenarios will be added to the hydrologic and hydraulic analyses.

HYDROLOGY

The Miner Slough watershed covers a tidally influenced slough approximately 7.8 miles long that begins from Sutter Slough and ends at the Yolo Bypass. Miner Slough is one of three distributaries of the Sacramento River in the tidal area on the eastern portion of Solano County.

Currently there are two flood profiles being used to estimate the water surface elevations throughout the Miner Slough project location. The first flood profile is the 1957 flood profile for the Sacramento River Flood Control Project, including Miner Slough, developed by the USACE. The design flood conditions for the USACE 1957 flood profile for Miner Slough are a design flood discharge of 10,000 cubic feet per second (cfs) and a peak stage of 19.24 feet (NAVD-88). The second flood profile used to calculate flood conditions within the project location is the flood profile of the January 1997 flood event through Miner Slough. This flood condition was developed by Caltrans’ Consultant CH2M-HILL and determined to be a 100-year flood event for the California

Delta region. The CH2M-HILL 1997 flood profile was developed and summarized in the technical memorandum produced by CH2M-HILL titled, “*Miner Slough Bridge Replacement: Sea Level Rise Impact Assessment*” (dated: May 2015). The design flood conditions for the CH2M-HILL 1997 flood profile are a 100-year discharge of 15,800 cfs and a peak stage of 15.8 feet (NAVD-88).

In addition to the two flood profiles, various SLR conditions were added to the hydrologic and hydraulic analyses. The SLR conditions were obtained from the technical memorandum produced by CH2M-HILL (as referenced above). The SLR conditions described in this technical memorandum are based on the SLR projections developed by the 2012 report by the National Research Council for sea level rise along the coasts of California, Oregon, and Washington. The SLR projections are based on a low, medium, and high probability of greenhouse gas emissions.

Table 1 provides the SLR projections, developed by the CH2M-HILL technical memorandum, for the Miner Slough replacement/rehabilitation project. As was discussed in the CH2M-HILL technical memorandum, as the channel flows increase the amount of SLR at the Miner Slough Bridge decreases. This result can be seen in Table 1 as the channel flows increase from 10,000 cfs (USACE 1957 Flood Profile) to 15,800 cfs (CH2M-HILL 1997 Flood Profile) the SLR projection decreases.

Table 1: Sea Level Rise Projections for Miner Slough Bridge Relative to the Year 2000 Baseline.

Flood Profile Condition	Sea Level Rise Projection Scenarios (feet)		
	Low SLR (B1)	Medium SLR (A1B)	High SLR (A1FI)
USACE 1957 Flood Profile	0.96	1.86	3.86
CH2M-HILL 1997 Flood Profile	0.8	1.6	3.1

HYDRAULIC RESULTS

In order to obtain USACE/CVFPB encroachment permits, the USACE requires that the Miner Slough Bridge be designed higher than the USACE 1957 flood profile conditions for Miner Slough. Caltrans was in talks with the USACE to adopt the CH2M-HILL 1997 flood profile for Miner Slough, as Caltrans and CH2M-HILL are of the opinion that the 1997 flood profile better fits current hydraulic and hydrologic conditions on Miner Slough. Currently, Caltrans has not received approval from the USACE to adopt the CH2M-HILL 1997 flood profile for design of the Miner Slough Bridge design alternatives; therefore, this preliminary hydraulic report will only provide the hydraulic results from the use of the USACE 1957 flood profile.

The USACE 1957 flood profile with the various SLR scenarios of Table 1 were modeled through the three hydraulic plans to calculate floodwater surface elevations throughout the project location. Table 2 summarizes the floodwater surface elevations of the three hydraulic plans at the upstream face of the Miner Slough Bridge at various SLR scenarios, including existing sea level conditions (the No SLR Scenario). As can be seen in Table 2, from the Existing Conditions to the two design alternatives, the water surface elevations had a near zero change. Therefore, the two design alternatives will not cause any backwater conditions that would adversely affect the channel to pass the design discharge of the USACE 1957 flood profile.

Analyzing the two design alternatives and existing conditions with the various SLR scenarios, all three hydraulic plans (pre-project to post-project conditions) will experience levee overtopping with

the high SLR scenario. All other SLR scenarios will be contained within the Miner Slough channel. Due to the flooding of the right bank (levee) during a high SLR condition, it does not seem necessary to design the proposed Miner Slough Bridge higher than a sea level rise event that floods the existing approach roadways. Therefore, it is recommended to design the proposed Miner Slough Bridge at the medium SLR scenario or lower for the USACE 1957 flood profile.

Table 2: Water Surface Elevations under Various Conditions at the Upstream Face of Miner Slough Bridge.

Hydraulic Modeling Plans	Water Surface Elevation ⁽¹⁾ (feet)			
	No SLR Scenario	With Low SLR Scenario	With Medium SLR Scenario	With High SLR Scenario
Existing Conditions Plan	19.36	20.31	21.20	23.18
Replacement Conditions Plan	19.36	20.30	21.19	23.17
Rehab Conditions Plan	19.36	20.31	21.19	23.18

Notes:

(1) – These water surface elevations do not take into account the required minimum freeboard (3.0 feet) required by the Central Valley Flood Protection Board.

Waterway Impacts:

Table 3 provides a summary of changes in water surface elevations (with a medium SLR scenario) comparing existing conditions (pre-project conditions) to the post-project conditions of the replacement and rehabilitation alternatives. A representative selection of river stations was chosen for the summary of Table 3.

The changes in water surface elevations from pre-project to post-project conditions was approximately 0.01 feet. This slight increase of floodwater elevations, at the proposed replacement alternative, is very minimal and demonstrates that the post-project flood elevations have the same hydraulic conditions as the pre-project conditions. It is important to note, that within the hydraulic modeling boundaries of the project location the maximum change of water surface elevations of 0.01 feet meets the 0.1 feet maximum rise in floodwaters within a floodway under the jurisdiction of the CVFPB. Both design alternatives, under a medium SLR scenario, will not adversely impact the designated floodway of Miner Slough.

Table 3: Floodwater Elevation Changes of Miner Slough due to the Two Design Alternatives With a Medium Sea Level Rise Scenario.

River Station (feet)	Water Surface Elevation (feet)			Δ Water Surface Elevation (feet)	
	Existing Conditions	Replacement Alternative Conditions	Rehab Alternative Conditions	Δ Existing to Replacement	Δ Existing to Rehab
5485.643	21.26	21.26	21.26	0	0
5152.411	21.25	21.25	21.25	0	0
4715.898	21.24	21.24	21.24	0	0
4339.978	21.23	21.22	21.23	-0.01	0
3873.332	21.21	21.21	21.21	0	0
3516.765	21.21	21.20	21.20	-0.01	-0.01
3190.444	21.20	21.20	21.20	0	0
3037.688	21.20	21.20	21.20	0	0

2958.131 ⁽¹⁾ Existing Bridge	21.20	21.19	21.19	-0.01	-0.01
2919.323	21.19	21.19	21.19	0	0
2869.053	21.19	21.19	21.19	0	0
2841.934 ⁽²⁾ Proposed Bridge	21.18	21.19	21.18	+0.01	0
2767.171	21.18	21.18	21.18	0	0
2692.783	21.17	21.17	21.17	0	0
2188.484	21.16	21.16	21.16	0	0
1707.182	21.14	21.14	21.14	0	0
1251.953	21.13	21.13	21.13	0	0
897.720	21.13	21.13	21.13	0	0
548.657	21.11	21.11	21.11	0	0
58.153	21.11	21.11	21.11	0	0

Notes:

(1) – River station of the upstream edge of deck of the existing and rehabbed Miner Slough Bridge.

(2) – River station of the upstream edge of deck of the proposed replacement structure for Miner Slough Bridge.

Bridge Freeboard Requirements:

Per the California Code of Regulations – Title 23 any construction or modification of bridges within a CVFPB designated floodway the proposed bridge’s soffit must be at least 3.0 feet above the design floodplain.

For the replacement alternative, the soffit elevation should be designed to be at least:

- Soffit Elevation = 21.19 ft (Medium SLR) + 3.0 ft (minimum required freeboard) = **24.2 feet**.

For the rehabilitation alternative, at a floodwater elevation of 21.19 feet (with a medium SLR scenario) plus the required freeboard of 3.0 feet for a total minimum soffit of 24.19 feet is approximately 4.12 feet above the soffit elevation of approximately 20.07 feet for the rehabbed existing Miner Slough Bridge. At this condition, the rehabilitation alternative will not meet the bridge standards for construction of the California Code of Regulations – Title 23.

However, according to Section §128 Bridges, Subsection (10)(B) there is a chance to apply for a variance to the freeboard requirement. Subsection (10)(B) states – “when an existing bridge being widened does not meet the clearance requirement above the floodplain, the bottom structural members of the added section may be no lower than the bottom structural members of the existing bridge, except as may be caused by the extension of the existing sloped structural members”.

This variance should be discussed with the CVFPB to determine if the rehabilitation alternative is a viable option. If the CVFPB provides the freeboard variance for the rehabilitation alternative, then this alternative is a very feasible solution to the Miner Slough Bridge project.

SCOUR ANALYSIS

A scour evaluation was performed for the two design alternatives for the proposed Miner Slough Bridge applying the USACE 1957 flood profile and in accordance with the guidelines set forth by the FHWA’s *Hydraulic Engineering Circular Number 18 – Evaluating Scour at Bridges, 5th Edition*.

Tables 4 and 5 provide the preliminary total scour depths for the replacement and rehabilitation design alternatives, respectively.

At the project location, the channel is flowing fairly straight under both design alternatives and the flood flows are contained within the channel, for all SLR scenarios except for the High SLR scenario, with the abutments outside of the floodwater elevations. Therefore, contraction scour is not expected to occur and will not be analyzed as part of the total scour conditions.

Channel degradation was also not included into the total scour conditions due to a lack of historical channel cross sections to make a proper determination.

As for the local scour conditions, only local pier and abutment scour was analyzed. Reviewing structure maintenance records and field photos revealed that significant debris loads have been reported and documented being lodged against various piers. Therefore, a debris load component based on the USACE requirements that all vertical elements, such as piles, will include a debris load that is double the width of the vertical element and extending down 2.0-feet below the design water surface elevation was added to the local pier scour analysis. The resulting local pier scour (as shown in Tables 4 and 5) ranges from 6.8 to 15.6 feet for the proposed replacement alternative and from 7.3 to 16.6 feet for the proposed rehabilitation alternative.

Table 4: Preliminary Scour Analysis for the Proposed Replacement Alternative.

Substructure Component	Short-Term Scour Depths	Long-Term Scour Depths		Total Scour Depth (feet)
	Local Scour ⁽¹⁾ (feet)	Degradation (feet)	Contraction Scour (feet)	
Abutment 1	0	0	0	0
Pier 2	6.8	0	0	6.8
Pier 3	15.6	0	0	15.6
Pier 4	6.8	0	0	6.8
Abutment 5	1.9	0	0	1.9

Notes:

(1) – Flood water levels did not reach the face of Abutment 1; therefore, this local scour component was not analyzed.

Table 5: Preliminary Scour Analysis for the Proposed Rehabilitation Alternative.

Substructure Component	Short-Term Scour Depths	Long-Term Scour Depths		Total Scour Depth (feet)
	Local Scour ⁽¹⁾ (feet)	Degradation (feet)	Contraction Scour (feet)	
Abutment 1	0	0	0	0
Pier 2	7.3	0	0	7.3
Pier 3	16.6	0	0	16.6
Pier 4	7.3	0	0	7.3
Pier 5	7.3	0	0	7.3
Abutment 6	2.4	0	0	2.4

Notes:

(1) – Flood water levels did not reach the face of Abutment 1; therefore, this local scour component was not analyzed.

According to the existing 1952 as-built Log of Test Borings, Miner Slough Bridge’s foundations in the channel rest on alternating layers of very soft clayey silt and stiff clay grading to sandy clay,

medium dense clayey silt and clayey sand. In the banks around the channel, the foundation material is mostly stiff silty clay that is underlain by medium dense fine gravel and poorly graded sand. This preliminary scour evaluation assumes there is nothing unique about the soils supporting the existing bridge that would prevent scour from reaching the predicted depths. In addition, the Office of Geotechnical Support concluded in their preliminary geotechnical evaluation, “that the soil material encountered at the site should be considered scourable”.

SUMMARY/RECOMMENDATIONS

The purpose of this preliminary hydraulic evaluation is to analyze the feasibility of the proposal of replacing or rehabilitating the existing Miner Slough Bridge and to determine if any hydraulic impacts are involved with these design alternatives. As a result, preliminary hydraulic and scour analyses indicates that the two design alternatives will not cause any significant hydraulic or scour related issues. It was determined that post-project flood conditions will remain the same as the pre-project conditions. Therefore, from a hydraulic standpoint both design alternatives are feasible to replace the existing Miner Slough Bridge.

The following are the conclusions and recommendations for each design alternative:

The Replacement Alternative

- The proposed replacement bridge for the Miner Slough Bridge will allow the channel to pass the design flood discharge without raising the design floodwater elevations.
- The predicted total scour depths for the proposed replacement bridge are calculated to be approximately 6.8 feet for Pier 2, 15.6 feet for Pier 3, 6.8 feet for Pier 4, and 1.9 feet for Abutment 5 below original grade.
- It is recommended to design this replacement alternative with a medium SLR projection.
- It is recommended to design the proposed replacement structure with a minimum soffit elevation of 24.2 feet. This soffit elevation will allow the proposed replacement bridge to pass the design flood elevation at a medium SLR projection (21.19 feet) plus the required freeboard (3.0 feet) to meet the construction standards of Title 23 of the California Code of Regulations.

The Rehabilitation Alternative

- The proposed rehabilitation of the existing Miner Slough Bridge will allow the channel to pass the design flood discharge without raising the design floodwater elevations.
- The predicted total scour depths for the proposed rehabilitation alternative are calculated to be approximately 7.3 feet for Pier 2, 16.6 feet for Pier 3, 7.3 feet for Pier 4, 7.3 feet for Pier 5, and 2.4 feet for Abutment 6 below original grade.
- It is recommended to design the rehabilitation alternative with a medium SLR projection.
- With a floodwater elevation at a medium SLR projection (21.19 feet) plus the required freeboard (3.0 feet), this design elevation of 24.19 feet is approximately 4.12 feet above the rehabbed Miner Slough Bridge’s soffit elevation of 20.07 feet. Consequently, the rehabilitation alternative will not meet the freeboard requirements for construction of Title 23 of the California Code of Regulations. However, according to Section §128 Bridges, Subsection (10)(B), there is a chance to apply for a variance for the freeboard requirement. If the rehabilitation alternative is worth pursuing further than it is recommended to apply for this variance through the CVFPB.